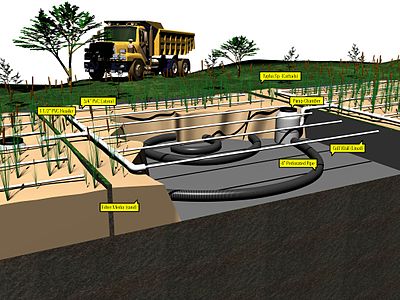
# Constructed wetland

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| [Mergefrom.svg](http://en.wikipedia.org/wiki/File:Mergefrom.svg) | It has been suggested that [*Treatment wetland*](http://en.wikipedia.org/wiki/Treatment_wetland) be [merged](http://en.wikipedia.org/wiki/Wikipedia:Merging) into this article or section. ([Discuss](http://en.wikipedia.org/wiki/Talk:Constructed_wetland)) |

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| http://upload.wikimedia.org/wikipedia/en/f/f4/Ambox_content.png | This article **is missing** [**citations**](http://en.wikipedia.org/wiki/Wikipedia:Citing_sources) **or needs** [**footnotes**](http://en.wikipedia.org/wiki/Wikipedia:Footnotes). Please help add [inline citations](http://en.wikipedia.org/wiki/Wikipedia:Inline_citations) to guard against copyright violations and factual inaccuracies. *(April 2008)* |

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Vertical Flow type of Constructed Wetlands

A **constructed wetland** or **wetpark** is an artificial [wetlands](http://en.wikipedia.org/wiki/Wetland), a [marsh](http://en.wikipedia.org/wiki/Marsh) or [swamp](http://en.wikipedia.org/wiki/Swamp) created: as new or restored [habitat](http://en.wikipedia.org/wiki/Habitat) for native and migratory [wildlife](http://en.wikipedia.org/wiki/Wildlife); for anthropogenic discharge such as [wastewater](http://en.wikipedia.org/wiki/Wastewater), [stormwater](http://en.wikipedia.org/wiki/Stormwater) runoff, or [sewage treatment](http://en.wikipedia.org/wiki/Sewage_treatment); for land reclamation after [mining](http://en.wikipedia.org/wiki/Mining), [refineries](http://en.wikipedia.org/wiki/Refinery), or other ecological disturbances; and as required [mitigation](http://en.wikipedia.org/wiki/Mitigation) for natural wetlands lost to a development.

Natural [wetlands](http://en.wikipedia.org/wiki/Wetland) act as a [biofilter](http://en.wikipedia.org/wiki/Biofilter), removing [sediments](http://en.wikipedia.org/wiki/Sediment) and [pollutants](http://en.wikipedia.org/wiki/Pollutant) such as [heavy metals](http://en.wikipedia.org/wiki/Heavy_metal_%28chemistry%29) from the water, and constructed wetlands can be designed to emulate these features.

**Subsurface-flow wetlands**

Subsurface-flow wetlands can be further classified as horizontal flow and vertical flow constructed wetlands. Subsurface-flow wetlands move effluent (agricultural or mining [runoff](http://en.wikipedia.org/wiki/Runoff_%28water%29), [tannery](http://en.wikipedia.org/wiki/Tanning) or [meat](http://en.wikipedia.org/wiki/Meat) processing wastes, wastewater from sewage or [storm drains](http://en.wikipedia.org/wiki/Storm_drain), or other water to be cleansed) through a [gravel](http://en.wikipedia.org/wiki/Gravel) [lavastone](http://en.wikipedia.org/wiki/Lava_filter) or [sand](http://en.wikipedia.org/wiki/Sand) medium on which plants are rooted. In subsurface-flow systems, the effluent may move either horizontally, parallel to the surface, or vertically, from the planted layer down through the substrate and out. Subsurface horizontal-flow wetlands are less hospitable to [mosquitoes](http://en.wikipedia.org/wiki/Mosquito), whose populations can be a problem in constructed wetlands. [Carnivorous plants](http://en.wikipedia.org/wiki/Carnivorous_plant) have been used to address this problem.[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia:Citation_needed)] Subsurface-flow systems have the advantage of requiring less land area for water treatment, but are not generally as suitable for wildlife habitat as are surface-flow constructed wetlands.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Constructed_wetland&action=edit&section=5)**] Surface-flow wetlands**

Surface-flow wetlands move effluent above the soil in a planted marsh or swamp, and thus can be supported by a wider variety of soil types including [bay mud](http://en.wikipedia.org/wiki/Bay_mud) and other [silty](http://en.wikipedia.org/wiki/Silt) [clays](http://en.wikipedia.org/wiki/Clay).

Plantings of [reedbeds](http://en.wikipedia.org/wiki/Reedbed) are popular in European constructed wetlands, and plants such as cattails (*[Typha](http://en.wikipedia.org/wiki/Typha" \o "Typha)* spp.), [sedges](http://en.wikipedia.org/wiki/Cyperaceae), Water Hyacinth (*[Eichhornia crassipes](http://en.wikipedia.org/wiki/Eichhornia_crassipes" \o "Eichhornia crassipes)*) and [*Pontederia*](http://en.wikipedia.org/wiki/Pontederia) spp. are used worldwide. Recent research in use of constructed wetlands for subarctic regions has shown that buckbeans (*[Menyanthes trifoliata](http://en.wikipedia.org/wiki/Menyanthes" \o "Menyanthes)*) and pendant grass (*[Arctophila fulva](http://en.wikipedia.org/wiki/Arctophila" \o "Arctophila)*) are also useful for metals uptake.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Constructed_wetland&action=edit&section=6)**] General contaminants removal**

Physical, chemical, and biological processes combine in wetlands to remove contaminants from wastewater. An understanding of these processes is fundamental not only to designing wetland systems but to understanding the fate of chemicals once they enter the wetland. Theoretically, wastewater treatment within a constructed wetland occurs as it passes through the wetland medium and the plant [rhizosphere](http://en.wikipedia.org/wiki/Rhizosphere_%28ecology%29). A thin film around each root hair is [aerobic](http://en.wikipedia.org/wiki/Aerobic) due to the leakage of oxygen from the [rhizomes](http://en.wikipedia.org/wiki/Rhizome), [roots](http://en.wikipedia.org/wiki/Root), and [rootlets](http://en.wikipedia.org/w/index.php?title=Rootlet&action=edit&redlink=1).[[1]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-0) Aerobic and [anaerobic](http://en.wikipedia.org/wiki/Anaerobic) micro-organisms facilitate decomposition of organic matter. Microbial [nitrification](http://en.wikipedia.org/wiki/Nitrification) and subsequent [denitrification](http://en.wikipedia.org/wiki/Denitrification) releases [nitrogen](http://en.wikipedia.org/wiki/Nitrogen) as gas to the [atmosphere](http://en.wikipedia.org/wiki/Atmosphere). [Phosphorus](http://en.wikipedia.org/wiki/Phosphorus) is [coprecipitated](http://en.wikipedia.org/wiki/Coprecipitation) with [iron](http://en.wikipedia.org/wiki/Iron), [aluminium](http://en.wikipedia.org/wiki/Aluminium), and [calcium](http://en.wikipedia.org/wiki/Calcium) compounds located in the [root-bed medium](http://en.wikipedia.org/w/index.php?title=Root-bed_medium&action=edit&redlink=1).[[2]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-1)[[3]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-2)[[4]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-fried55-3)[[5]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-sah86-4)[[6]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Patrick-Reddy-1976-5) [Suspended solids](http://en.wikipedia.org/wiki/Suspended_solids) filter out as they settle in the water column in surface flow wetlands or are physically filtered out by the medium within subsurface flow wetland cells. Harmful [bacteria](http://en.wikipedia.org/wiki/Bacteria) and [viruses](http://en.wikipedia.org/wiki/Virus) are reduced by filtration and adsorption by [biofilms](http://en.wikipedia.org/wiki/Biofilm) on the [rock media](http://en.wikipedia.org/w/index.php?title=Rock_media&action=edit&redlink=1) in subsurface flow and vertical flow systems.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Constructed_wetland&action=edit&section=7)**] Specific contaminants removal**

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Constructed_wetland&action=edit&section=8)**] Nitrogen removal**

The dominant forms of nitrogen in wetlands that are of importance to [wastewater treatment](http://en.wikipedia.org/wiki/Wastewater_treatment) include [organic nitrogen](http://en.wikipedia.org/w/index.php?title=Organic_nitrogen&action=edit&redlink=1), [ammonia](http://en.wikipedia.org/wiki/Ammonia), [ammonium](http://en.wikipedia.org/wiki/Ammonium), [nitrate](http://en.wikipedia.org/wiki/Nitrate), [nitrite](http://en.wikipedia.org/wiki/Nitrite), and [nitrogen gases](http://en.wikipedia.org/wiki/Nitrogen_gases). [Inorganic](http://en.wikipedia.org/wiki/Inorganic) forms are essential to plant growth in [aquatic systems](http://en.wikipedia.org/w/index.php?title=Aquatic_systems&action=edit&redlink=1) but if scarce can limit or control plant productivity.[[7]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-6) Total Nitrogen refers to all nitrogen species. Wastewater nitrogen removal is important because of ammonia’s toxicity to fish if discharged into watercourses. Excessive nitrates in drinking water is thought to cause [methemoglobinemia](http://en.wikipedia.org/wiki/Methemoglobinemia) in infants, which decreases the blood's oxygen transport ability. The UK has experienced a significant increase in nitrate concentration in [groundwater](http://en.wikipedia.org/wiki/Groundwater) and rivers.[[8]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-7)

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Constructed_wetland&action=edit&section=9)**] Organic nitrogen**

Mitsch & Gosselink define nitrogen [mineralisation](http://en.wikipedia.org/wiki/Mineralisation) as "the biological transformation of organically combined nitrogen to ammonium nitrogen during organic matter degradation".[[9]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Mitsch-Gosselink-1986-8) This can be both an [aerobic](http://en.wiktionary.org/wiki/aerobic) and [anaerobic](http://en.wiktionary.org/wiki/anaerobic) process and is often referred to as [ammonification](http://en.wikipedia.org/wiki/Ammonification). Mineralisation of organically combined nitrogen releases inorganic nitrogen as nitrates, nitrites, ammonia and ammonium, making it available for plants, [fungi](http://en.wikipedia.org/wiki/Fungi) and bacteria.[[9]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Mitsch-Gosselink-1986-8) Mineralisation rates may be affected by [oxygen](http://en.wikipedia.org/wiki/Oxygen) levels in a wetland.[[6]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Patrick-Reddy-1976-5)

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Constructed_wetland&action=edit&section=10)**] Ammonia removal**

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Constructed_wetland&action=edit&section=11)**] NH3) and ammonium (NH+4)**

The formation of ammonia (NH3) occurs via the mineralisation or ammonification of organic matter under either anaerobic or aerobic conditions.[[10]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-keeney73-9) The ammonium [ion](http://en.wikipedia.org/wiki/Ion) (NH+4) is the primary form of mineralized nitrogen in most flooded wetland soils. This ion forms when ammonia combines with water as follows:

NH3 + H2O ⇌ NH+4 + OH −[[9]](http://en.wikipedia.org/wiki/Constructed_wetland" \l "cite_note-Mitsch-Gosselink-1986-8)

Upon formation, several pathways are available to the ammonium ion. It can be absorbed by plants and [algae](http://en.wikipedia.org/wiki/Algae) and converted back into organic matter, or the ammonium ion can be electrostatically held on negatively charged surfaces of soil particles.[[9]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Mitsch-Gosselink-1986-8) At this point, the ammonium ion can be prevented from further [oxidation](http://en.wikipedia.org/wiki/Oxidation) because of the anaerobic nature of wetland soils. Under these conditions the ammonium ion is stable and it is in this form that nitrogen predominates in anaerobic [sediments](http://en.wikipedia.org/wiki/Sediments) typical of wetlands.[[6]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Patrick-Reddy-1976-5)[[11]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-10)

Most wetland soils have a thin aerobic layer at the surface. As an ammonium ion from the anaerobic sediments diffuses upward into this layer it converts to nitrite or nitrified.[[12]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-klop78-11) An increase in the thickness of this aerobic layer results in an increase in nitrification.[[6]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Patrick-Reddy-1976-5) This diffusion of the ammonium ion sets up a [concentration gradient](http://en.wikipedia.org/wiki/Concentration_gradient) across the aerobic-anaerobic soil layers resulting in further nitrification reactions.[[6]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Patrick-Reddy-1976-5)[[12]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-klop78-11)

[Nitrification](http://en.wikipedia.org/wiki/Nitrification) is the biological conversion of organic and inorganic nitrogenous compounds from a reduced state to a more oxidized state.[[13]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Wetzel-1983-12) Nitrification is strictly an aerobic process in which the end product is nitrate (NO−3); this process is limited when anaerobic conditions prevail.[[6]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Patrick-Reddy-1976-5) Nitrification will occur readily down to 0.3 [ppm](http://en.wikipedia.org/wiki/Parts_per_million) dissolved oxygen.[[10]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-keeney73-9) The process of nitrification (1) oxidizes ammonium (from the sediment) to nitrite (NO−2), and then (2) nitrite is oxidized to nitrate (NO−3). The overall nitrification reactions are as follows:

(1) 2NH+4 + 3O2 ⇌ 4H+ + 2H2O + 2NO−2  
(2) 2NO−2 + O2 ⇌ 2NO−3  
(Davies & Hart, 1990)

Two different bacteria are required to complete this oxidation of ammonium to nitrate. [*Nitrosomonas*](http://en.wikipedia.org/wiki/Nitrosomonas) sp. oxidizes ammonium to nitrite via reaction (1), and [*Nitrobacter*](http://en.wikipedia.org/wiki/Nitrobacter) sp. oxidizes nitrite to nitrate via reaction (2).[[10]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-keeney73-9)

[**Denitrification**](http://en.wikipedia.org/wiki/Denitrification) is the biochemical reduction of oxidized nitrogen anions, nitrate (NO−3) and nitrite (NO−2) to produce the gaseous products nitric oxide (NO), nitrous oxide (N2O) and nitrogen gas (N2), with concomitant oxidation of organic matter.[[13]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Wetzel-1983-12) The general sequence is as follows:

NO−3 → NO−2 → NO → N2O → N2

The end products, N2O and N2 are gases that re-enter the atmosphere. Denitrification occurs intensely in anaerobic environments but also in aerobic conditions.[[14]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-13) Oxygen deficiency causes certain bacteria to use nitrate in place of oxygen as an [electron acceptor](http://en.wikipedia.org/wiki/Electron_acceptor) for the reduction of organic matter.[[6]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Patrick-Reddy-1976-5) Denitrification is restricted to a narrow zone in the sediment immediately below the aerobic-anaerobic soil interface.[[9]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Mitsch-Gosselink-1986-8)[[15]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-14) Denitrification is considered to be the predominant microbial process that modifies the chemical composition of nitrogen in a wetland system and the major process whereby elemental nitrogen returns to the atmosphere.[[6]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-Patrick-Reddy-1976-5)[[16]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-15) To summarize, the [nitrogen cycle](http://en.wikipedia.org/wiki/Nitrogen_cycle) is completed as follows: ammonia in water, at or near neutral [pH](http://en.wikipedia.org/wiki/PH) is converted to ammonium ions; the aerobic bacterium *Nitrosomonas* sp. oxidizes ammonium to nitrite; *Nitrobacter* sp. then converts nitrite to nitrate. Under anaerobic conditions, nitrate is reduced to relatively harmless nitrogen gas that enters the atmosphere.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Constructed_wetland&action=edit&section=12)**] Domestic sewage - ammonia**

In a review of 19 surface flow wetlands it was found that nearly all reduced total nitrogen.[[17]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-16) A review of both surface flow and subsurface flow wetlands concluded that effluent nitrate concentration is dependent on maintaining anoxic conditions within the wetland so that denitrification can occur and that subsurface flow wetlands were superior to surface flow wetlands for nitrate removal. The 20 surface flow wetlands reviewed reported effluent nitrate levels below 5 mg/L; the 12 subsurface flow wetlands reviewed reported effluent nitrate ranging from <1 to < 10 mg/L.[[18]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-17) Results obtained from the Niagara-On-The-Lake vertical flow systems show a significant reduction in both total nitrogen and ammonia (> 97%) when primary treated effluent was applied at a rate of 60L/m²/day. Calculations showed that over 50% of the total nitrogen going into the system was converted to nitrogen gas. Effective removal of nitrate from the sewage lagoon influent was dependent on medium type used within the vertical cell as well as water table level within the cell.[[19]](http://en.wikipedia.org/wiki/Constructed_wetland#cite_note-18)

<http://en.wikipedia.org/wiki/Constructed_wetland#Subsurface-flow_wetlands>

**Biofiltration**

Vegetation in a wetland provides a substrate (roots, stems, and leaves) upon which [microorganisms](http://en.wikipedia.org/wiki/Microorganism) can grow as they break down organic materials. This community of microorganisms is known as the [periphyton](http://en.wikipedia.org/wiki/Periphyton). The periphyton and natural chemical processes are responsible for approximately 90 percent of [pollutant](http://en.wikipedia.org/wiki/Pollutant) removal and waste breakdown. The plants remove about seven to ten percent of pollutants, and act as a [carbon](http://en.wikipedia.org/wiki/Carbon) source for the microbes when they decay. Different species of [aquatic plants](http://en.wikipedia.org/wiki/Aquatic_plant) have different rates of heavy metal uptake, a consideration for plant selection in a constructed wetland used for water treatment. Constructed wetlands are of two basic types: subsurface-flow and surface-flow wetlands.

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| [Newly planted constructed wetland.jpg](http://en.wikipedia.org/wiki/File:Newly_planted_constructed_wetland.jpg) | [Mature Constructed Wetland.jpg](http://en.wikipedia.org/wiki/File:Mature_Constructed_Wetland.jpg) |